# Municipal Solid Waste Disposal

An Overview of Emerging Technologies

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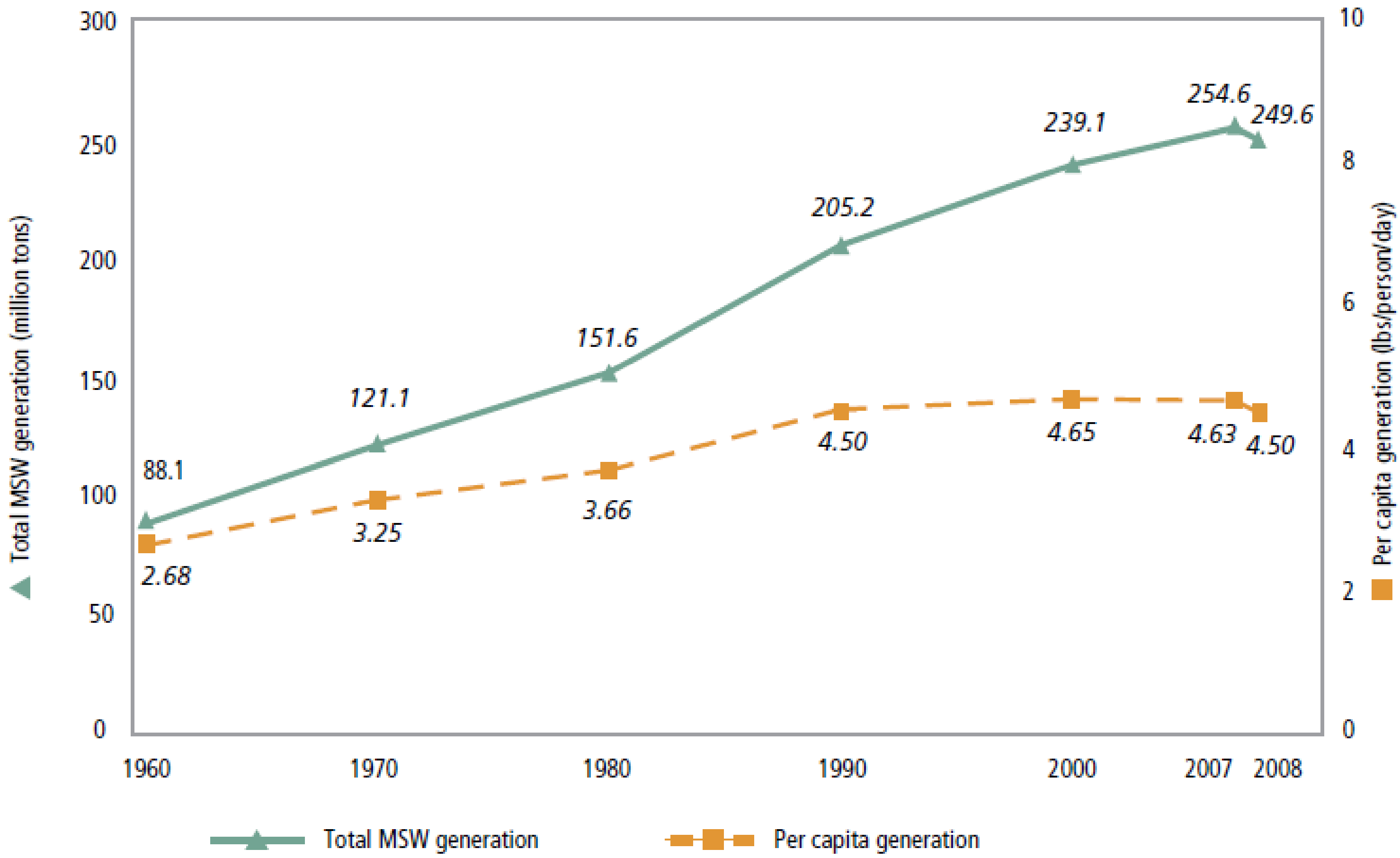
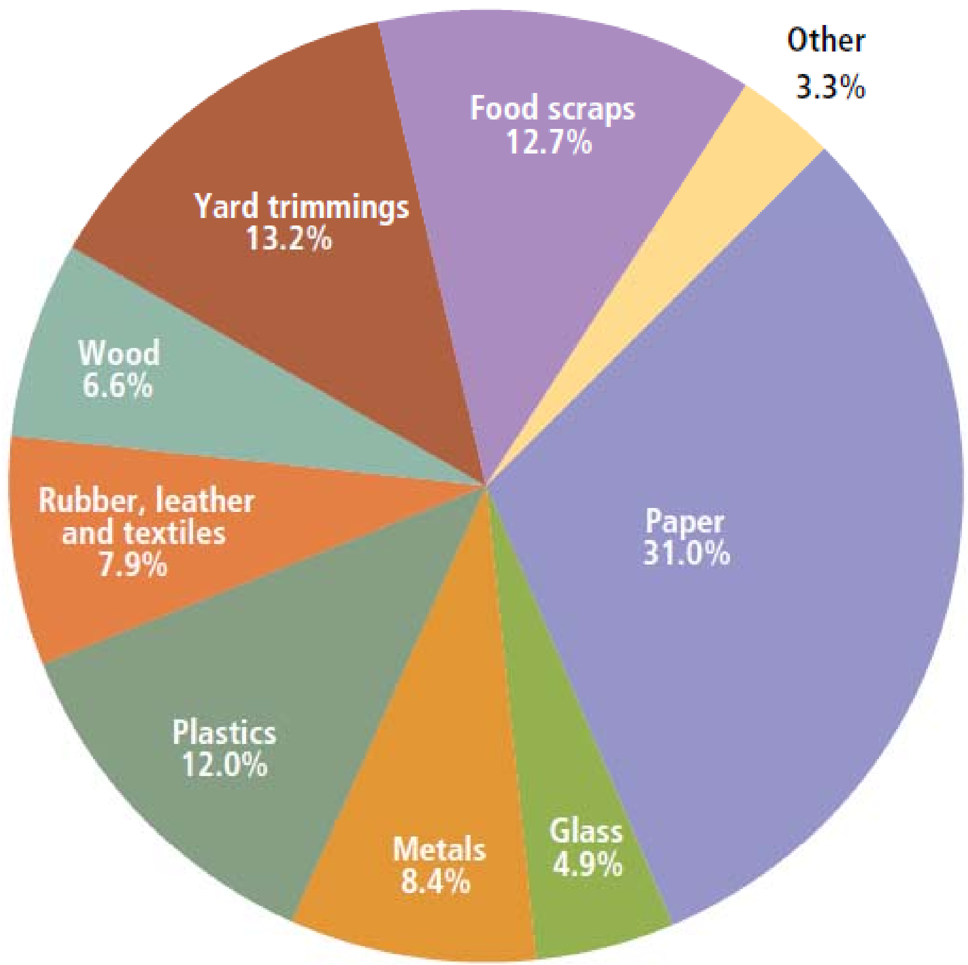
# MSW Generation Rates, 1960 to 2008



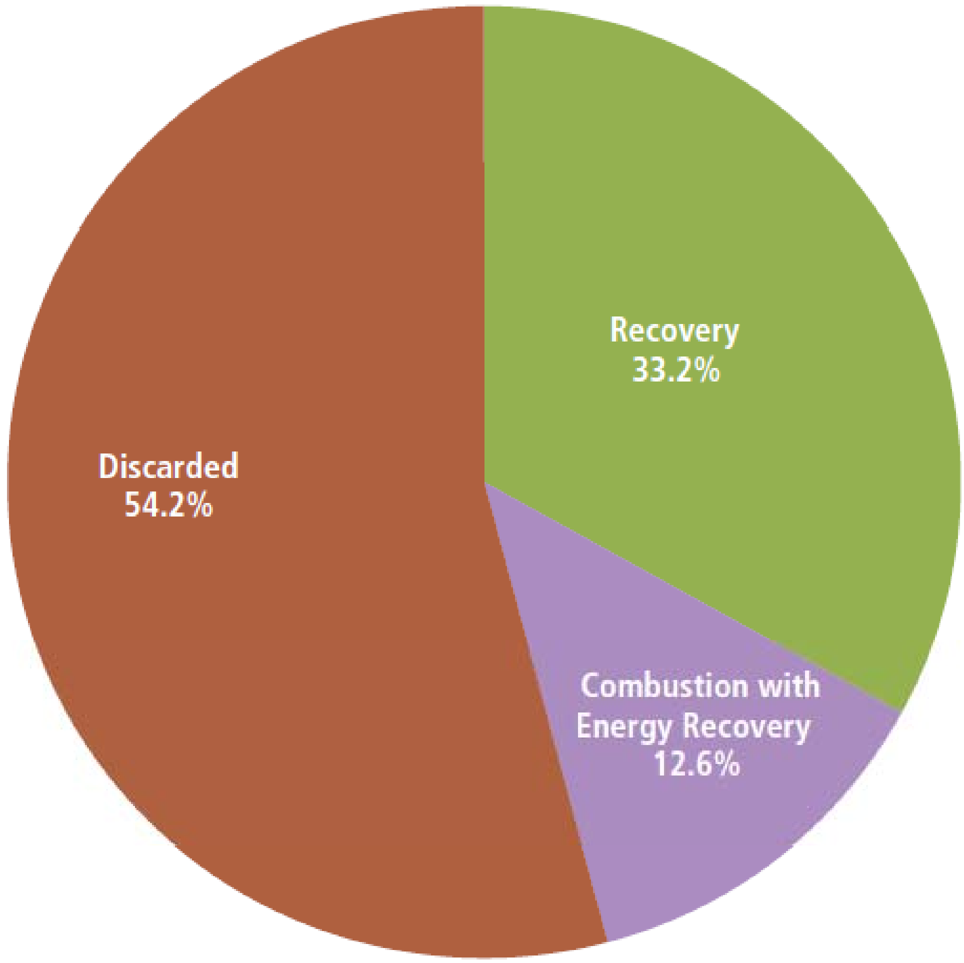

Source: U.S. EPA, 2009

## Total Municipal Solid Waste (MSW) Generation by Waste Type, 2008
## 250 Million Tons (before recycling)



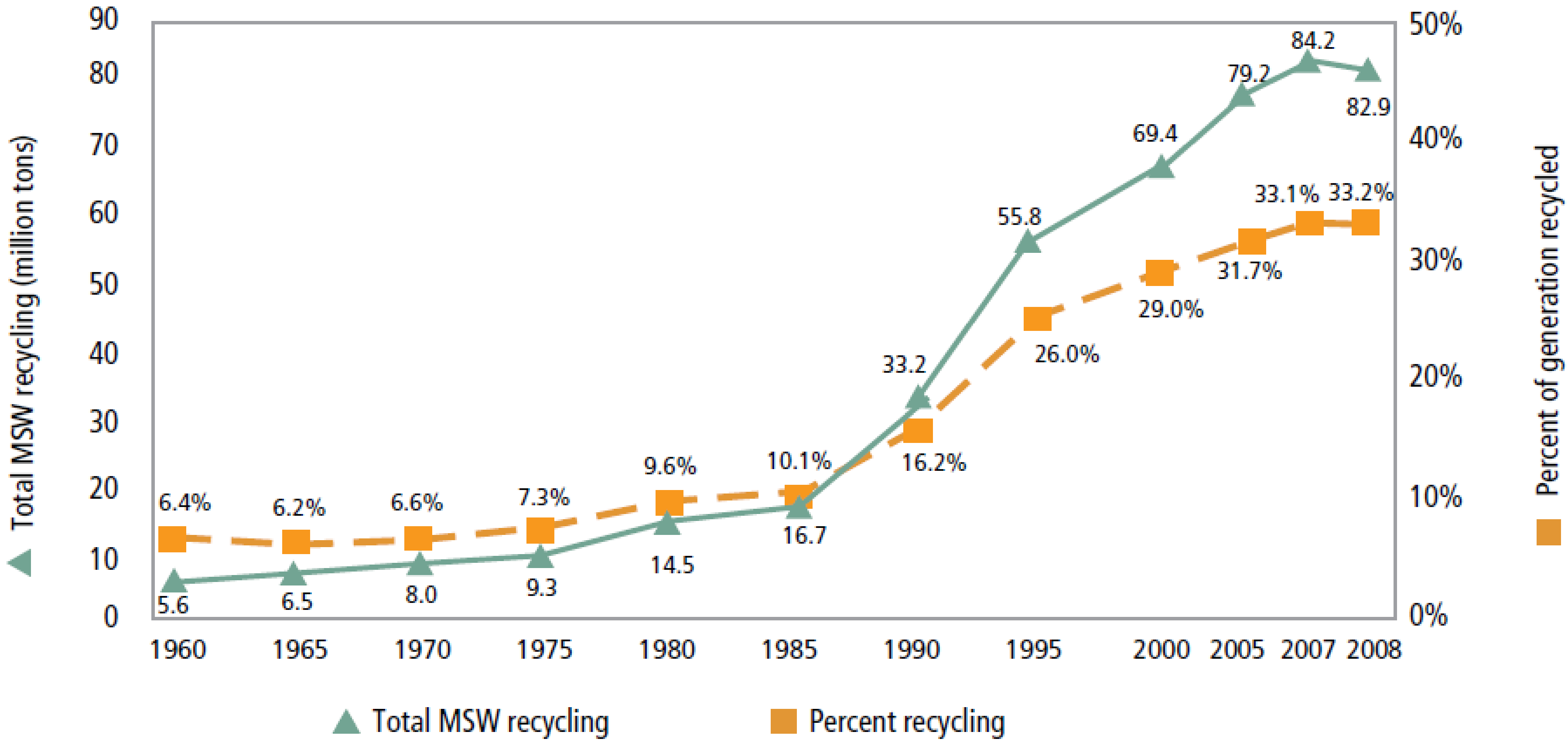

Source: U.S. EPA, 2009

# Management of MSW in the U.S.




Source: U.S. EPA, 2009

# MSW Recycling Rates, 1960 to 2008



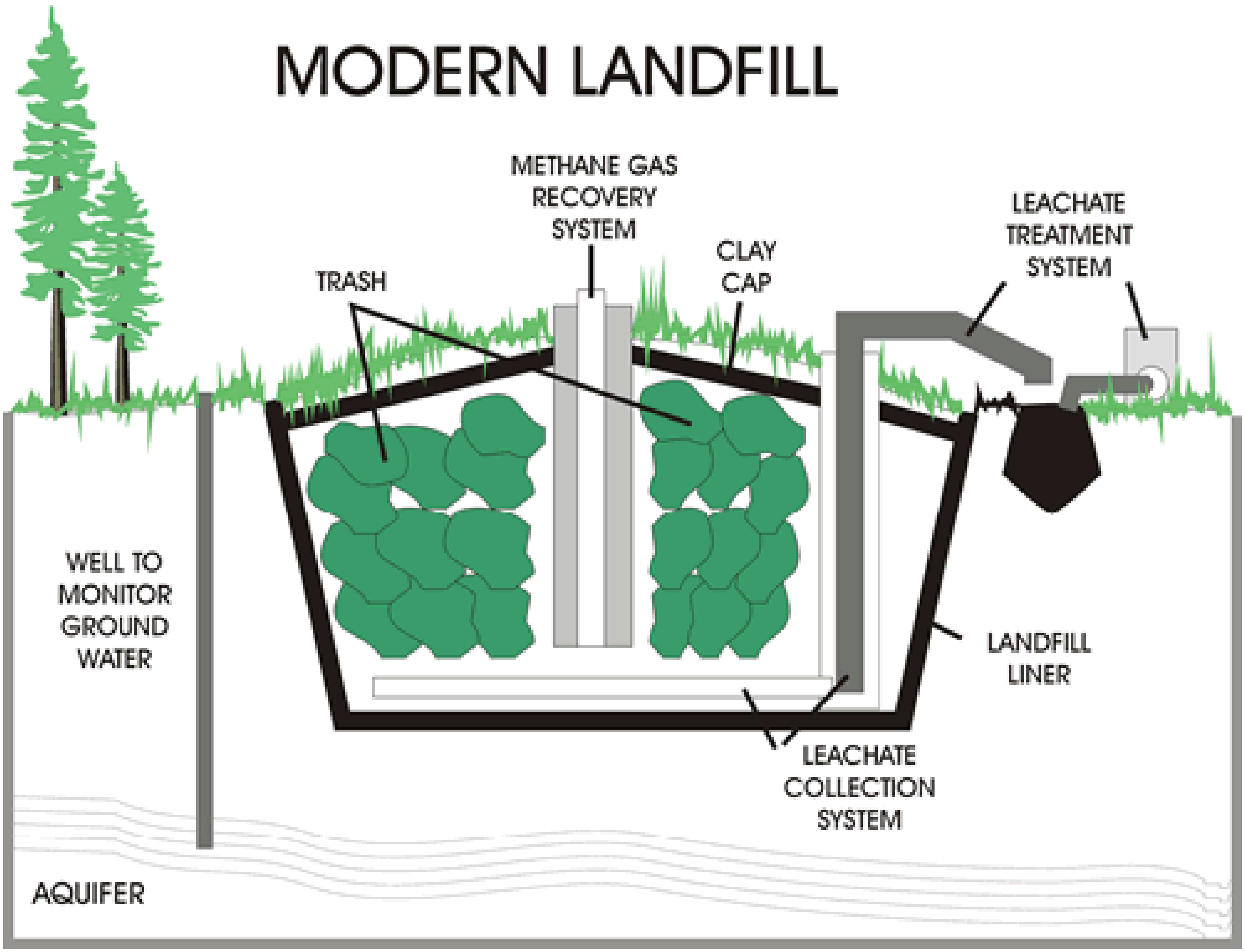

Source: U.S. EPA, 2009

# Current Solid Waste Management Practices

- Landfills
- Incineration
- Composting
- Recycling

# Landfill Gas Recovery

Methane Capture and Use




http://tonto.eia.doe.gov/energyexplained/index.cfm?page=biomass_biogas

# Landfill Gas

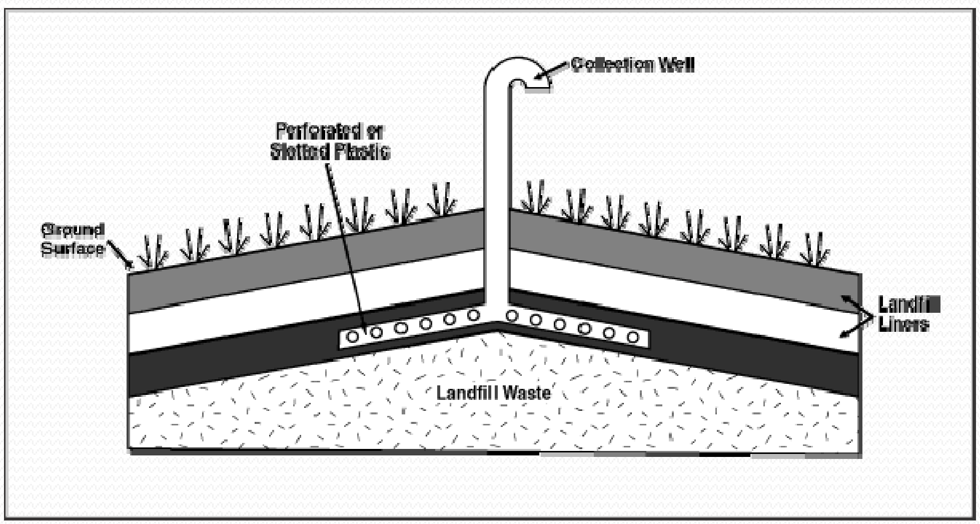
- Landfill gas is composed of a mixture of hundreds of different gases.
- By volume, landfill gas typically contains 45% to 60% methane and 40% to 55% carbon dioxide.
- Methane = natural gas
  - Colorless and odorless
  - Regulations require landfills to collect landfill gas as a pollution and safety measure.

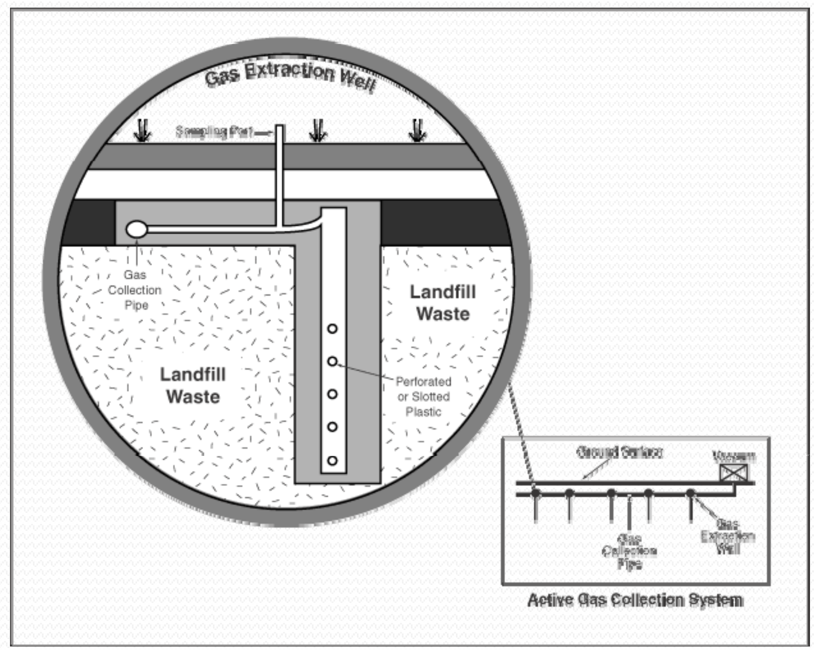
# Landfill Gas

- Landfill gas is the single largest source of man-made methane emissions in the United States, contributing to almost 40% of methane emissions each year.
- Consequently, a growing trend at landfills across the country is to use recovered methane gas from landfills as an energy source.

# Landfill Gas Collection

- Landfill gas can be collected by either a passive or an active collection system.
- A typical collection system, either passive or active, is composed of a series of gas collection wells placed throughout the landfill.



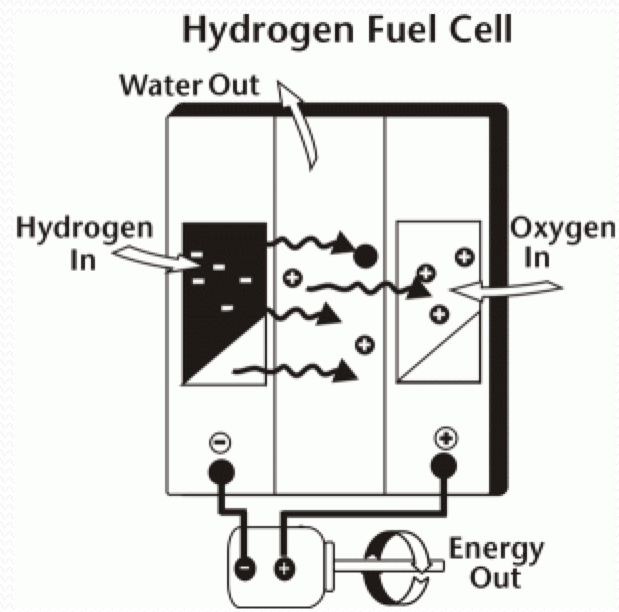



# Landfill Gas Use

- Common methods to treat and/or use landfill gas include:
  - Combustion
    - Flares, incinerators, boilers, gas turbines, and internal combustion engines
    - Produces SOx, NOx, carbon monoxide, and particulates
  - Non-combustion
    - Requires pretreatment to remove impurities such as water, non-methane organic constituents, and carbon dioxide

# Non-combustion Technologies

- Fuel cells:
  - Converts hydrogen (from methane – $CH_4$) to electricity
  - Expensive, but costs are decreasing
- Gas-to-product conversion technologies:
  - Converts gas into commercial products
    - Compressed or liquefied natural gas
    - Methanol
    - Purified carbon dioxide and methane



# Alternate Solid Waste Disposal Technologies

The Future of Solid Waste Management

# Technology Categories

- Thermal conversion
- Digestion
- Hydrolysis
- Mechanical processing for fiber recovery

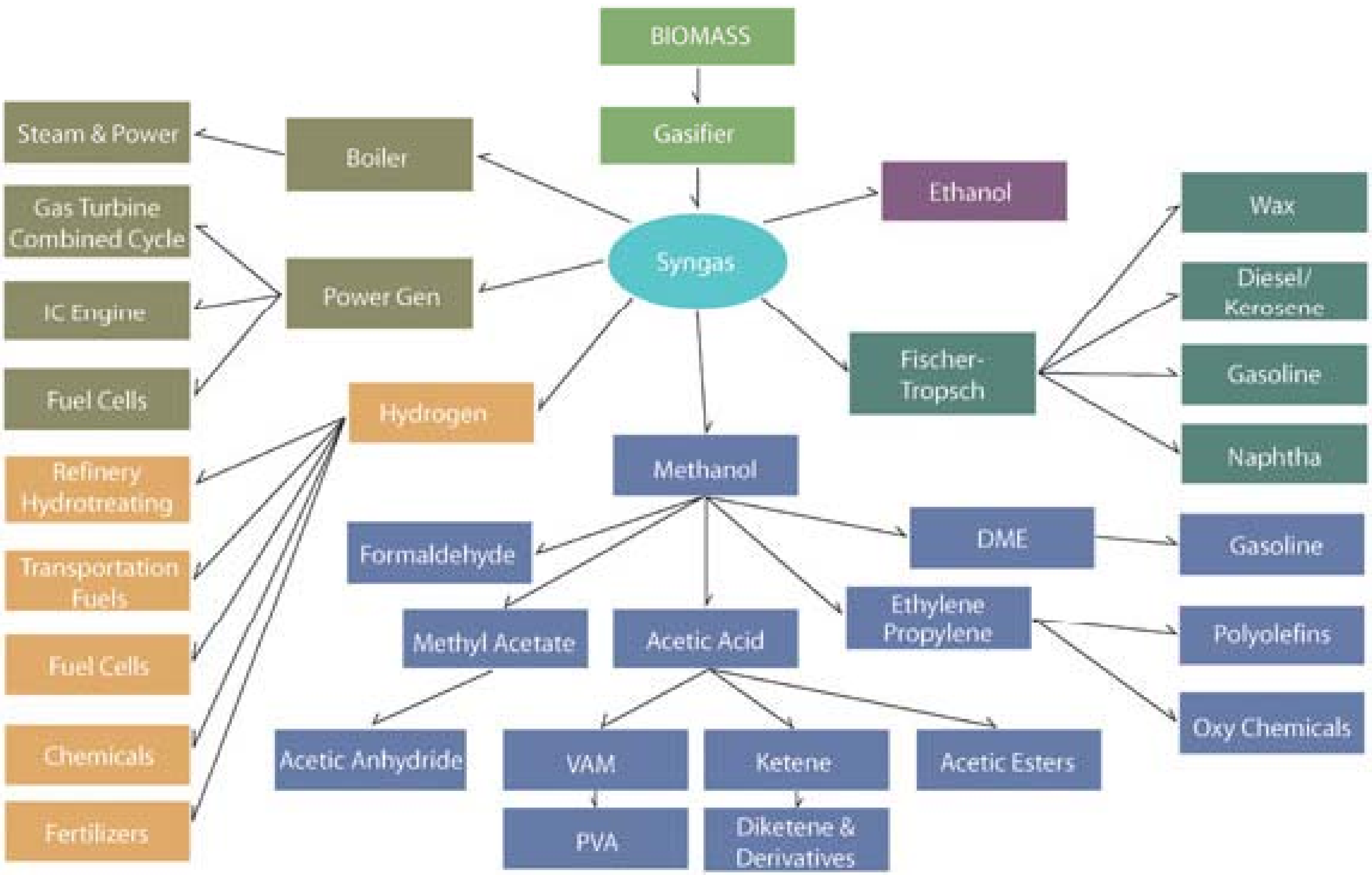
# Thermal Conversion Process

- Use of heat to convert waste feedstock into gases, oils, specialty chemicals, solid char and fertilizers.
- Typically requires a high degree of pre-processing (i.e. – sorting, shredding, drying)
- Common thermal technologies include:
  - Gasification
  - Pyrolysis
  - Plasma Arc

# Gasification and Pyrolysis

- Heats organic carbon-based materials to high temperatures with limited oxygen (gasification) or no oxygen (pyrolysis).
- Produces:
  - Synthesis gas (syngas) – hydrogen and carbon monoxide
  - Carbon dioxide
  - Oils (pyrolysis oil)
  - Char and ash

# Gasification – Options for Bio-based Products



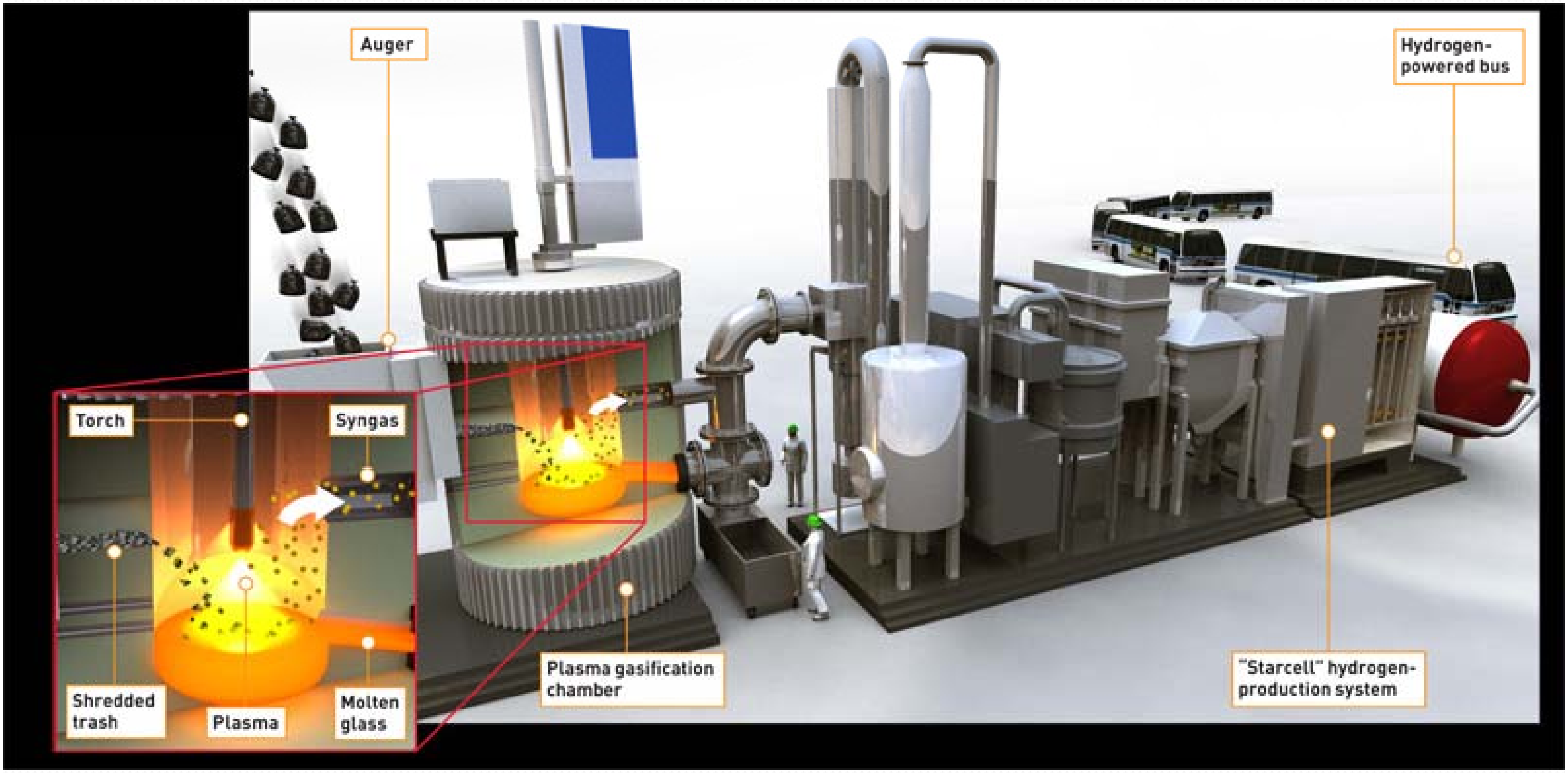
# Gasification and Pyrolysis

- After cooling and cleaning, the syngas can be used directly or further processed to produce methanol, ethanol and other liquid fuels that can be used in boilers or internal combustion engines to generate electricity.

- Reduces solid waste volume by 70-90 percent.
- No commercial-scale plants exist yet in the U.S.

# Plasma Arc Gasification

- Uses high temperature plasma to heat waste to 7,200 to 12,600 degrees F and break it down into basic elemental components.
- Products include:
  - Syngas
  - Vitrified solids (slag)
  - Metals
  - Salts




http://cyberdesignworks.com/s/media/blog/longo_b_800-717941.jpg

# Plasma Arc Gasification

- Advantages over other thermal technologies:
  - Requires no pre-sorting since it can handle all types of waste (including hazardous or toxic materials, medical waste, asbestos, etc…)
  - Compounds are completely broken down in a closed system, so there are no air emissions.
- Issues:
  - Expensive
  - No commercial-scale facilities built yet in the U.S., but two are planned in Florida.

# Digestion

- About 50% of MSW is biodegradable.
- Digestion is the reduction of solid organic waste materials through decomposition by microbes, accompanied by the evolution of liquids and gases.
- The biological process of digestion may be aerobic or anaerobic, depending on whether oxygen is introduced into the process.

# Anaerobic Digestion

- Organic material is decomposed in the absence of oxygen, producing a solid byproduct and a gas (biogas).
- Used extensively to stabilize sewage sludge.
- The biogas produced from anaerobic digestion is primarily methane and carbon dioxide.
- Biogas is commonly burned in an internal combustion engine to generate electricity.
- The solid byproduct material may be used as a soil conditioner or compost.

# Aerobic Digestion

- The organic fraction of MSW is metabolized by microorganisms in the presence of oxygen.
- Generates carbon dioxide and water.
- The digested material may be used as a soil amendment or fertilizer (compost).
- Unlike the process of anaerobic digestion, no methane gas is produced in this process.

# Hydrolysis

- Conversion of the cellulosic fraction of MSW(paper, food waste, yard waste) to ethanol or other chemicals, and carbon dioxide.
- The application of this technology for MSW is still at the demonstration scale.

# Fiber Recovery

- Involves the mechanical processing of MSW to recover fiber for use in paper making.
- The biomass fraction of the waste is collected and pulped.
- The long-fiber pulp is recovered for paper making, and the sludge is anaerobically digested.
- The organic fraction that is not recoverable as a paper pulp substitute is combusted.

# Conclusions

- Promising technologies and technology applications are emerging that allow not only for the disposal of MSW, but for conversion of waste into energy and/or useful byproducts.
- Many of these technologies have been implemented in Europe, Japan, and China, but have yet to be implemented in the U.S.
- Several factors will contribute favorably to the cost-effectiveness of these practices in the future, namely:
  - Population increase
  - Urban expansion
  - Carbon emission caps?
  - Higher energy costs
  - Increased competition for natural resources

# Caveats

- It will probably take longer for these technologies to be cost competitive in our region due to:
  - Relatively low volumes of MSW when compared to large urban areas.
  - Cheap and abundant electricity.
  - Low costs to purchase land.
  - Abundant land and space.

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# Extending the Life of a Landfill

Extension vs. Reduction

# Reduction of Waste

- Between 1960 and 2008 the amount of waste each person creates has almost doubled from 2.7 to 4.5 pounds per day.
- The most effective way to stop this trend is by preventing waste in the first place.
- Since 1977, the weight of 2-liter plastic soft drink bottles was reduced from 68 grams to 51 grams resulting in 250 million pounds of plastic per year kept out of the waste stream.

# Extending the Life of a Landfill

- Recycling
  - Recycling glass, metals, construction and demolition debris, yard waste, plastics, wood, and paper products.
- Composting
  - MSW typically contains 70-80% organic material.
- Leachate Recirculation
  - Accelerate waste stabilization and gas production rates, reduce landfill volume, decrease long-term liability, and improve leachate control.

# Extending the Life of a Landfill

- Alternative daily cover
  - Daily cover removal is not an efficient process; 10-20% of the soil remains in the fill.
- Shredding
  - Shredding can increase the density of the MSW by 15% over unprocessed refuse.
- Compaction equipment
  - Improper equipment selection will lead to underutilization of landfill space.